

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2008 question paper

9701 CHEMISTRY

9701/32

Paper 32 (Practical 2), maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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UNIVERSITY of CAMBRIDGE
International Examinations

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| Skill | | Breakdown of marks | |
|---|----------|--|---------|
| Manipulation, measurement and observation | 16 marks | Successful <u>collection</u> of data and observations | 8 marks |
| | | <u>Quality</u> of measurements and observations | 4 marks |
| | | <u>Decisions</u> relating to measurements or observations | 4 marks |
| Presentation of data and observations | 12 marks | <u>Recording</u> data and observations | 5 marks |
| | | <u>Display</u> of calculation and reasoning | 3 marks |
| | | Data <u>layout</u> | 4 marks |
| Analysis, conclusions and evaluation | 12 marks | <u>Interpretation</u> of data or observations and identifying sources of error | 6 marks |
| | | Drawing <u>conclusions</u> | 5 marks |
| | | Suggesting <u>improvements</u> | 1 mark |

Statement Bank

MANIPULATION, MEASUREMENT AND OBSERVATION (MMO)

Successful collection of data and observations (Collection)

| | |
|-----------|---|
| C1 | Set up apparatus correctly |
| C2 | Follow instructions given in the form of written instructions or diagrams |
| C3 | Use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials |
| C4 | Make measurements using pipettes, burettes, measuring cylinders, thermometers, and other common laboratory apparatus |

Quality of measurements or observations (Quality)

| | |
|-----------|--|
| Q1 | Make accurate and consistent measurements and observations |
|-----------|--|

Decisions relating to measurements or observations (Decisions)

| | |
|------------|---|
| De1 | Decide how many tests or observations to perform |
| De2 | Make measurements that span a range and have a distribution appropriate to the experiment |
| De3 | Decide how long to leave experiments running before making readings |
| De4 | Identify where repeated readings or observations are appropriate |
| De5 | Replicate readings or observations as necessary |
| De6 | Identify where confirmatory tests are appropriate and the nature of such tests |

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PRESENTATION OF DATA AND OBSERVATIONS (PDO)

Recording of data and observations (Recording)

| | |
|-----------|--|
| R1 | Present numerical data, values or observations in a single table of results |
| R2 | Draw up the table in advance of taking readings/making observations so that they do not have to copy up their results |
| R3 | Include in the table of results, if necessary, columns for raw data, for calculated values and for analyses or conclusions |
| R4 | Use column headings that include both the quantity and the unit and that conform to accepted scientific conventions |
| R5 | Record raw readings of a quantity to the same degree of precision and observations to the same level of data |

Display of calculation and reasoning (Display)

| | |
|------------|--|
| Di1 | Show their working in calculations, and the key steps in their reasoning |
| Di2 | Use the correct number of significant figures for calculated quantities |

Data layout (Layout)

| | |
|-----------|--|
| L1 | Choose a suitable and clear method of presenting the data, e.g. tabulations, graph or mixture of methods of presentation |
| L2 | Use the appropriate presentation medium to produce a clear presentation of the data |
| L3 | Select which variables to plot against which and decide whether the graph should be drawn as a straight line or a curve |
| L4 | Plot appropriate variables on clearly labelled x- and y- axes |
| L5 | Choose suitable scales for graph axes |
| L6 | Plot all points or bars to an appropriate accuracy |
| L7 | Follow the ASE recommendations for putting lines on graphs |

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ANALYSIS, CONCLUSIONS AND EVALUATION (ACE)

Interpretation of data or observations and identify sources of error (Interpretation)

| | |
|------------|---|
| I1 | Describe the patterns and trends shown by tables and graphs |
| I2 | Describe and summarise the key points of a set of observations |
| I3 | Find an unknown value by using co-ordinates or intercepts on a graph |
| I4 | Calculate other quantities from data, or calculate the mean from replicate values, or make other appropriate calculations |
| I5 | Determine the gradient of a straight line |
| I6 | Evaluate the effectiveness of control variables |
| I7 | Identify the most significant sources of error in an experiment |
| I8 | Estimate, quantitatively, the uncertainty in quantitative measurements |
| I9 | Express such uncertainty in a measurement as an actual or percentage error |
| I10 | Show an understanding of the distinction between systematic errors and random errors |

Drawing conclusions (Conclusions)

| | |
|-------------|--|
| Con1 | Draw conclusions from an experiment, giving an outline description of the main features of the data, considering whether experimental data supports a given hypothesis, and making further predictions |
| Con2 | Draw conclusions from interpretations of observations, data and calculated values |
| Con3 | Make scientific explanations of the data, observations and conclusions that they have described |

Suggesting Improvements (Improvements)

| | |
|-------------|--|
| Imp1 | Suggest modifications to an experimental arrangement that will improve the accuracy of the experiment or the accuracy of the observations that can be made |
| Imp2 | Suggest ways in which to extend the investigation to answer a new question |
| Imp3 | Describe such modifications clearly in words or diagrams |

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| Skill | Total marks | Breakdown of marks | | | Question 1 | Question 2 | Question 3 |
|---|--------------------|--|--------------|---|-------------------|-------------------|-------------------|
| | | Statement | Marks | | | | |
| Manipulation, measurement and observation (MMO) | 16 marks | Successful <u>collection</u> of data and observations | C | 8 | 1 | 1 | 6 |
| | | <u>Quality</u> of measurements and observations | Q | 4 | 2 | 2 | 0 |
| | | <u>Decisions</u> relating to measurements of observations | De | 4 | 1 | 0 | 3 |
| Presentation of data and observations (PDO) | 12 marks | <u>Recording</u> data or observations | R | 5 | 1 | 3 | 1 |
| | | <u>Display</u> of calculation and reasoning | Di | 3 | 3 | 0 | 0 |
| | | Data <u>layout</u> | L | 4 | 1 | 1 | 2 |
| Analysis, conclusions and evaluation (ACE) | 12 marks | <u>Interpretation</u> of data or observations and identifying sources of error | I | 6 | 3 | 3 | 0 |
| | | <u>Drawing conclusions</u> | Con | 5 | 0 | 1 | 4 |
| | | <u>Suggesting improvements</u> | Imp | 1 | 0 | 1 | 0 |
| Total | | | | | 12 | 12 | 16 |

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Question 1

Supervisor's Report

Check all subtractions in (a). Use the titres, corrected where necessary, to select the "best average" titre to be used as an accuracy standard using the following hierarchy.

- value of 2 identical titres
- average of titres within 0.05 cm³
- average of titres within 0.10 cm³, etc.

Calculate, **correct to 2 dp**, the titre if the Supervisor had diluted 41.50 cm³ of **FB 2**. Do not round calculated averages to nearest 0.05 cm³.

This is given by the expression $\frac{41.50}{\text{vol diluted}} \times \text{titre}$

Record this value on the Supervisor's script and on all candidate scripts against the titration table.

Candidate scripts

Check and correct all subtractions as above.

Examiner is to select best titre as above, (**do not include values labelled rough unless crossed out or ticked/used by candidate**) and calculate the scaled titre for 41.50 cm³ of **FB 2**.

If no volume of **FB 2** diluted has been given, assume candidate has used 41.50 cm³.

Record the value against the titration table and calculate the difference to Supervisor.

| Question | Sections | Statement | Indicative material | Mark | |
|----------|-------------------|-----------|--|------|-----|
| 1 (a) | PDO Layout | L1 | (i) Records initial and final burette readings in each of the tables <i>(If 50.00 cm³ is used as initial burette reading, treat as 0.00 cm³. Do not award (i) in this case or if 50.00 cm³ is given as a repeated final burette reading in the 2nd table)</i> | 1 | |
| | PDO Recording | R5 | (ii) All accurate burette readings in the titration table recorded to nearest 0.05 cm ³ <i>Treat 1st titration as rough unless the candidate has crossed out a "rough" label or used the value in calculating the average</i> | 1 | |
| | MMO Collection | C2 | (iii) Follows instructions – Dilutes 41.00 cm ³ to 42.00 cm ³ (uncorrected) of FB 2 | 1 | |
| | MMO Decisions | De5 | (iv) Has two or more uncorrected titres within 0.1 cm ³ <i>Titres labelled "rough" may be included</i> | 1 | |
| | MMO Quality | Q1 | Accuracy Award (v) and (vi) if difference from Supervisor's value is 0.3 cm ³ or less | 2 | |
| | | Q1 | Award (v) only for a difference of 0.3+ cm ³ to 0.6 cm ³ | | [6] |

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|-------------|--------------------|--|--|-----------|-----|
| (b) | ACE Interpretation | I4 | Candidate selects/calculates correct “average” from titre values within 0.2 cm ³ . <i>Average must be calculated correct to 2dp or nearest 0.05 cm³ if burette read to 2dp/0.05 cm³. For burette readings, consistent to 1dp the average may be correct to 1 or 2 dp)</i> | 1 | [1] |
| (c) | ACE Interpretation | I4 | Award (i) for $\frac{\text{vol diluted}}{1000} \times \frac{28.44}{158}$ in 1 st step | 1 | [5] |
| | | I4 | Award (ii) for (× 2.5) in 1 st equation step and for (× 2) in 2 nd equation step | 1 | |
| | PDO Display | Di1 | (iii) Working shown in at least three of the first four steps <i>Correct or incorrect combination of half-equations into an equation for the reaction counts as working</i> | 1 | |
| | Di2 | (iv) 3 or 4 significant figures given in each answer attempted for sections 1–4. <i>A Minimum of two sections attempted is required before this mark can be awarded.</i> | 1 | | |
| | | Di2 | (v) Award one mark for Answer to step 4 $\times \frac{1000}{\text{titre}}$ correctly evaluated to 3 sig fig. (Examiner to check) <i>Allow ± 1 in 3rd sig fig.</i> <i>It may be necessary to check any calculation in which numbers have been “carried” in a calculator</i> | 1 | |
| Qn 1 | Total | | | 12 | |

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|---|--------------------|----------|--|---|-----|
| 2 (a) | PDO Layout | L1 | (i) 4 balance readings + mass of X_2CO_3 and mass of CO_2 clearly shown for at least one of the two experiments | 1 | [4] |
| | PDO Recording | R1 | (ii) single table incorporating balance readings for FB 6 and FB 7 or balance readings for the flask + mass of X_2CO_3 | 1 | |
| | | R4 | (iii) table has correct headings and units <i>Accept only:</i> <i>/ g; (g); or mass of..... in grams</i> <i>If not included in heading every entry must be followed by g</i> | 1 | |
| | | R5 | (iv) all of the balance readings recorded are consistent to 1 dp, 2 dp, etc. <i>showing the precision of the balance used</i> | 1 | |
| <p>For FB 6 and FB 7 Examiners calculate (check and correct candidate working if necessary)</p> <ul style="list-style-type: none"> the mass of carbonate that reacted the mass of carbon dioxide given off mass of carbonate (to 2 dp) giving 1.0 g of carbon dioxide. | | | | | |
| (b) | ACE Interpretation | I4 | Accurately calculates to 1 or 2 decimal places the mass of X_2CO_3 giving 1.0 g of CO_2 for FB 6 and FB 7 <i>If the balance used reads to 2 dp the candidate must give an answer to 2 dp.</i> | 1 | [3] |
| | MMO Quality | Q1 Q1 | Accuracy Award two marks for a difference up to 0.3 g in the mass of carbonate in FB 6 and FB 7 giving 1.0 g of CO_2 Award one mark only for a difference of 0.3+ g to 0.6 g. Award no Q marks if any mass of CO_2 is negative or any mass $CO_2 >$ corresponding mass of X_2CO_3 | 2 | |

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| (c) | ACE Interpretation | 14 | <p>Give one mark for using the following expression for either FB 6 or FB 7</p> $\frac{\text{candidate's mass of carbonate}}{\text{candidate's mass of carbon dioxide}} \times 44$ <p>or (candidate's value in (b) × 44)</p> <p><i>This is a mark for using the correct expression and not a mark for the actual value calculated or for sig fig.</i></p> <p><i>Beware calculations leading to A_r of X</i></p> | 1 | [1] |
| (d) | ACE Interpretation | 17 | <p>Give one mark for identifying one of the following as the significant error</p> <ul style="list-style-type: none"> • loss of acid spray • solid stuck to the sides of the flask • diffusion time for the CO₂ <p><i>Do not allow spillage as a source of error.</i></p> <p><i>Mark multiple answers (±), ignoring any true but irrelevant suggestions</i></p> | 1 | [1] |
| (e) | ACE Improvements | Imp1 | <p>Give one mark if the candidate states that loss of carbon dioxide can be reduced by one of the following</p> <ul style="list-style-type: none"> • warming the solution (to expel dissolved gas) • saturating the acid with CO₂ before starting the experiment • extended swirling or shaking • using a smaller volume of more concentrated acid • waiting a longer time before taking the final reading | 1 | [1] |

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|-------------|--------------------|------|---|-----------|-----|
| (f) | MMO Collection | C3 | <p>The candidate should observe:</p> <ul style="list-style-type: none"> • BaCO_3 insoluble in water (powder remains) • X_2CO_3 soluble in water (colourless/clear solution) • effervescence/fizzing/bubbling with X_2CO_3 and acid • more rapid reaction in acid for X_2CO_3 than BaCO_3 <i>accept comparison of effervescence including no apparent bubbling with BaCO_3 and bubbling with X_2CO_3</i> <p>Give the mark for three out of the four correct boxes providing at least one has a reference to evolution of gas with acid.</p> <p>Give one mark for formation of insoluble barium sulphate. or barium sulphate is a white precipitate</p> | 1 | [2] |
| | ACE Conclusions | Con3 | | 1 | |
| Qn 2 | Total | | | 12 | |

FB 9 is aqueous ammonium bromide ($\text{NH}_4\text{C1/NaBr}$), FB 10 is aqueous aluminium sulphate, FB 11 is aqueous lead(II) nitrate.

Selection of reagents – Accept any of the following:

- a named compound or a recognisable (but not necessarily correct) formula for the compound
- aqueous ions, e.g. $\text{Ba}^{2+}(\text{aq})$
- a solution containing a named ion

Identification of unknowns – Accept either of the following:

- a named compound (or ion)
- a **fully correct** formula for the compound or ion

| Question | Sections | Statement | Indicative material | Mark |
|----------|------------------|-----------|--|------|
| 3 (a) | PDO Layout | L1 | (i) Give one mark for presenting observations for all 6 tests in a clear fashion. | 1 |
| | PDO Recording | R1 | (ii) Give one mark for a single table showing observation on adding of NaOH and NH_3 and when the reagent is in excess where an initial precipitate has been formed. | 1 |

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|-----|--------------------|------|--|---|-----|
| | MMO Collection | C3 | (iii) Give one mark for observing initial white ppt for FB 10 and FB 11 and no ppt / no reaction / clear or colourless solution with FB 9 <i>Observations for both reagents required</i> Do not give this mark if any white ppt turns brown | 1 | |
| | | C3 | (iv) Give one mark for recorded precipitates soluble in excess NaOH and insol. in excess NH ₃ for FB 10 and FB 11 . | 1 | [4] |
| (b) | ACE Conclusions | Con2 | Mark consequentially from observations of white or off-white precipitates <i>(Ignore ions not listed in QA Notes)</i> Give one mark for concluding that FB 9 contains two of: NH ₄ ⁺ or Ba ²⁺ or Ca ²⁺ (in low concentration). | 1 | |
| | | Con2 | Give one mark for concluding that FB 10 and FB 11 could contain Pb ²⁺ or Al ³⁺ . <i>Allow this conclusion from:</i> (i) <i>an off-white ppt, soluble in excess NaOH and insoluble in excess NH₃</i> (ii) <i>a white ppt sparingly soluble in NH₃</i> <i>For:</i> <i>white ppt insoluble in excess NaOH and excess NH₃ accept a conclusion of Mg²⁺ and Mn²⁺. Allow Mn²⁺ from white ppt turning brown</i> <i>Accept Zn²⁺, from white ppt soluble in excess NaOH and excess NH₃, for FB 10 or FB 11. Mn²⁺ or Mg²⁺ may also be selected as single ions from appropriate observations</i> | 1 | [2] |

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| (c) | MMO Decisions | De6 | <p>Check the ions selected. Where one ion only has been selected for FB 9, FB 10, or FB 11 a further test is still required as confirmation.</p> <p>(i) Give one mark for warming the solution with NaOH and testing for ammonia to identify NH_4^+ ion Test must be described in method or observation or for the use of dichromate or chromate to identify Ba^{2+} or eliminate Ca^{2+}</p> | 1 |
| | | De6 | <p>(ii) Give one mark for choosing one of the following to distinguish between Pb^{2+} and Al^{3+} HCl – barium chloride is not suitable, KI – solution FB 4, H_2SO_4 – solution FB 3, dichromate (VI), $\text{K}_2\text{Cr}_2\text{O}_7$, $\text{Cr}_2\text{O}_7^{2-}$ (aq) chromate (VI), K_2CrO_4, CrO_4^{2-} (aq)</p> <p>Use of $\text{K}_2\text{Cr}_2\text{O}_7/\text{K}_2\text{CrO}_4$ or H_2SO_4 as a single reagent is sufficient providing Ba^{2+} is one of <u>only two</u> ions selected for FB 9 in (b) and the reagent has been added to all three of the solutions.</p> | 1 |
| | MMO Collection | C3 | <p>(iii) Mark observations consequentially. The expected observations for possible combinations of reagents are given below.</p> | 1 |

| Reagent | FB 9 | FB 10 | FB 11 |
|--|-----------------------------|-----------|------------------|
| warm with NaOH | NH_3 gas liberated | no change | no change |
| HCl | no change | no change | white ppt |
| (allow observations also from BaCl_2) | no change | white ppt | ignore white ppt |
| KI | no change | no change | yellow ppt |
| H_2SO_4 | no change | no change | white ppt |
| $\text{Cr}_2\text{O}_7^{2-} / \text{CrO}_4^{2-}$ | no change | no change | yellow ppt |

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| | ACE Conclusions | Con2 | (iv) Give one mark for identifying: NH ₄ ⁺ in FB 9 – if NH ₄ ⁺ is one of possible ions; or Ca ²⁺ if Ca ²⁺ / Ba ²⁺ are selected ions. Al ³⁺ in FB 10 and Pb ²⁺ in FB 11 (NO e.c.f. in this section) | 1 | [4] | | | | | | | | | | | | | | | |
|--|------------------------|-----------|--|---|-----|---------|------|-------|---|-----------|-----------|-------------------|------------------------|-----------|----------------------------------|-------------------|--|-----------------------------------|-----------|-----------|
| (d) | MMO Decisions | De6 | (i) Give one mark for choosing BaCl ₂ / Ba(NO ₃) ₂ Pb(NO ₃) ₂ as one reagent and AgNO ₃ / Pb(NO ₃) ₂ as the other reagent. <i>(Pb²⁺ not acceptable as sole reagent)</i> | 1 | | | | | | | | | | | | | | | | |
| | PDO Layout | L1 | (ii) Give one mark for tabulating tests performed and the observations in those tests or presenting this information in other clear format. | 1 | | | | | | | | | | | | | | | | |
| | MMO Collection | C3 | (iii) Give one mark for appropriate observations with the first reagent (<i>see below</i>) | 1 | | | | | | | | | | | | | | | | |
| | | C3 | (iv) Give one mark for appropriate observations with the second reagent (<i>see below</i>) | 1 | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th>Reagent</th> <th>FB 9</th> <th>FB 10</th> </tr> </thead> <tbody> <tr> <td>BaCl₂ / Ba(NO₃)₂ (addition of HCl not required)</td> <td>no change</td> <td>white ppt</td> </tr> <tr> <td>AgNO₃</td> <td>off-white or cream ppt</td> <td>no change</td> </tr> <tr> <td>followed by NH₃(aq)</td> <td>partially soluble</td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>Pb(NO₃)₂</td> <td>white ppt</td> <td>white ppt</td> </tr> </tbody> </table> | | | | | | Reagent | FB 9 | FB 10 | BaCl ₂ / Ba(NO ₃) ₂ (addition of HCl not required) | no change | white ppt | AgNO ₃ | off-white or cream ppt | no change | followed by NH ₃ (aq) | partially soluble | | Pb(NO ₃) ₂ | white ppt | white ppt |
| Reagent | FB 9 | FB 10 | | | | | | | | | | | | | | | | | | |
| BaCl ₂ / Ba(NO ₃) ₂ (addition of HCl not required) | no change | white ppt | | | | | | | | | | | | | | | | | | |
| AgNO ₃ | off-white or cream ppt | no change | | | | | | | | | | | | | | | | | | |
| followed by NH ₃ (aq) | partially soluble | | | | | | | | | | | | | | | | | | | |
| Pb(NO ₃) ₂ | white ppt | white ppt | | | | | | | | | | | | | | | | | | |
| | MMO Collection | C3 | (v) Give one mark for partial solubility or insolubility in NH ₃ of the silver halide ppt formed with Ag ⁺ – if that reagent was used. | 1 | | | | | | | | | | | | | | | | |

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| | ACE Conclusions | Con2 | <p>(vi) Give one mark for concluding, from observations, that the anion in FB 10 is sulphate and the anion in FB 9 is bromide.</p> <p>Bromide ions cannot be identified if Ba²⁺/Pb²⁺ have been selected as the reagents.</p> <p><i>Allow the bromide conclusion from:</i></p> <p>(i) <i>off-white or cream precipitate with Ag⁺</i></p> <p>(ii) <i>white ppt with Ag⁺ partially soluble or insoluble in NH₃</i></p> <p><i>Allow a conclusion of iodide from a yellow ppt with Ag⁺ although this will not have scored the observation mark</i></p> | 1 | [6] |
| Qn 3 | Total | | | 16 | |